

Participant's Manual

Suspension E90



The information contained in this Participant's Manual is intended solely for the participants of this seminar run by BMW Aftersales Training.

Refer to the latest relevant "BMW Service" information for any changes/supplements to the Technical Data.

Information status: October 2004

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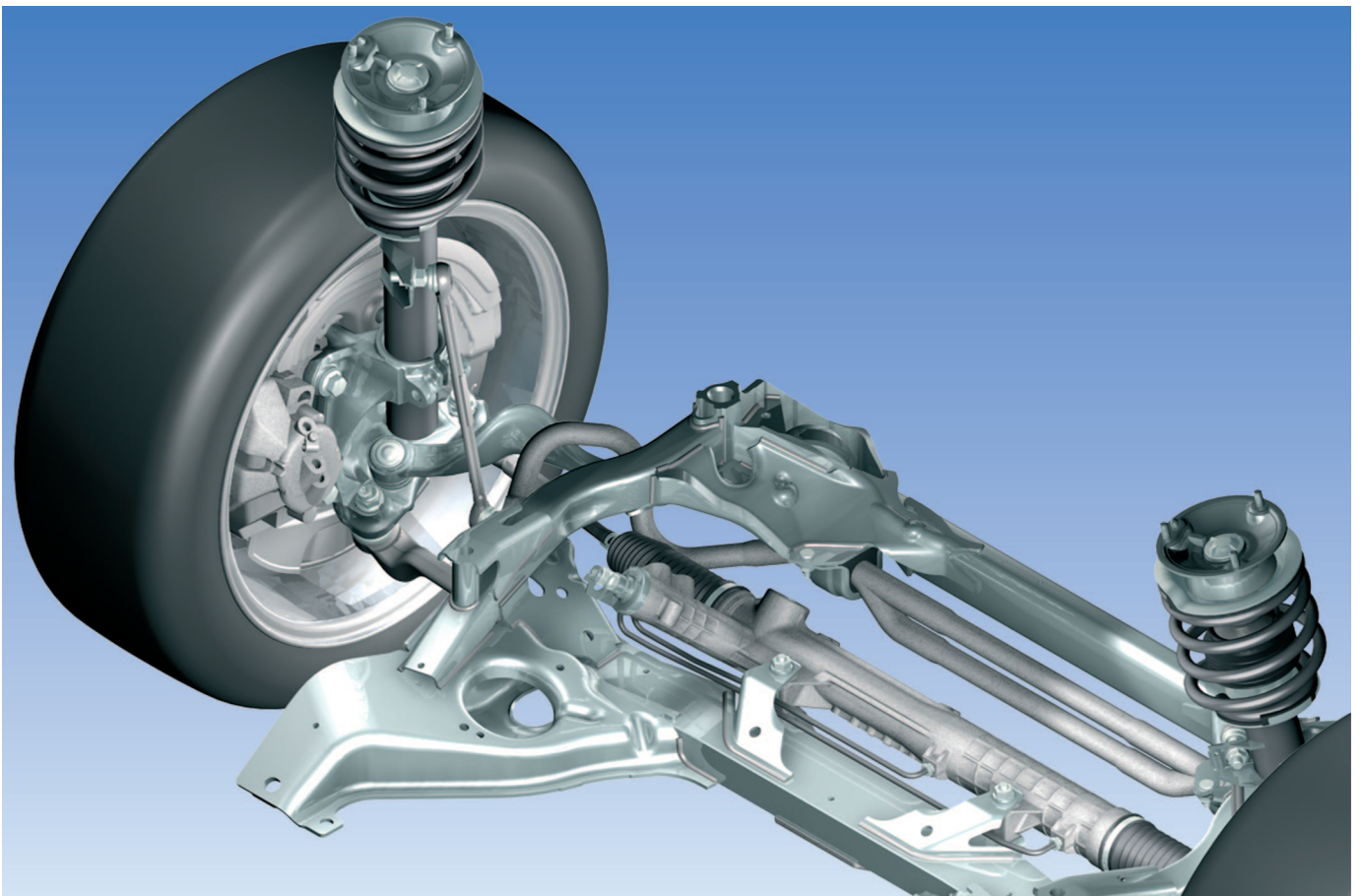
Participant's Manual

Suspension E90

Front axle

Rear axle


Electric steering lock (ELV)



Information on this Participant's Manual

Symbols used

The following symbols are used in this Participant's Manual to facilitate better comprehension and to draw attention to important information.

 contains information for better understanding of the described systems and their functions.

◀ identifies the end of an item of information.

Current content of Participant's Manual

In view of the constant further developments in the design and equipment of BMW vehicles deviations may arise between this Participant's Manual and the vehicles made available as part of the training course.

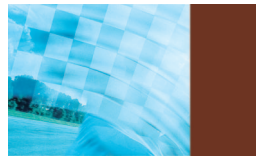
The background material refers exclusively to left-hand drive vehicles. The controls are in part arranged differently in right-hand drive vehicles than shown on the graphics in the Participant's Manual.

Additional information sources

You will find further information on the individual vehicle topic in the BMW diagnosis and repair systems as well as on the Internet under www.bmw.com.

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Objectives

Suspension E90

Purpose of this Participant's Manual

The Participant's Manual is a document designed to accompany a seminar while at the same time serving as a source of reference.

The front and rear axles and the electric steering lock (ELV) are described in this Participant's Manual.



Models

Suspension E90

Development of BMW rear axles

BMW chassis and suspension systems and therefore the sportive and dynamic character of the individual models have long been based on the special axle designs and, of course, on

the integral optimum chassis and suspension tuning.

The following table shows the development history of BMW rear axles:

| Explanation | Distinguishing features | Model |
|--------------|--|--|
| HA 1 | Semi-trailing arm axle | E3, E9, E12, E21, E28, E30, E36/5, E36/7, E114 |
| HA 2 | Screw-link axle | E23, E24, E32, E34 |
| HA 3 | Central-link rear axle | Z1, E36/2, E36/3, E36/4, E36/C, E46, E83, E85 |
| | Double lateral control arm axle | E26 |
| HA 4 | Experimental study | |
| HA 5 | Dispersed double control arm axle | E87, E90 |
| Integral I | Experimental study | |
| Integral II | Experimental study | |
| Integral III | | E31 |
| Integral IV | Steel, spring, damper tower | E38 |
| Integral IV | Aluminium, spring, damper tower | E39 |
| Integral IV | Aluminium, spring on body and damper on axle carrier | E39/2 |
| Integral IV | Steel axle carrier, aluminium link and steel wheel carrier, spring and damper separated but both supported on body | E53 |
| Integral IV | Aluminium axle carrier with cast node technology and cast swing arm, spring strut shock absorber tower | E65 |
| Integral IV | Aluminium axle carrier with cast node technology and cast swing arm, spring strut shock absorber tower | E6x |



Introduction

Suspension E90

Suspension E90



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1 - Front and rear axles in the E90

As can already be seen from the illustration, the chassis and suspension of the E90 represent a new step forward in the mid-size class both at the front axle as well as at the rear axle. The front axle is designed as a double pivot spring strut axle (MacPherson strut) in aluminium.

The design principle of the double pivot spring strut front axle of the E90 was installed in the E23 as early as 1977. At that time, however, it was installed with recirculating ball-and-nut steering behind the axle. The E90 and the E87 on the other hand feature front-mounted rack-and-pinion steering.

As opposed to the E87 front axle, the E90 features a new reinforcing strut. The balancing components - control arm and tension strut mounts - and the engine and transmission mounts have been adapted.

The rear axle has been completely redesigned as a five-link axle for the E87 and E90. The properties of the front and rear axles are described in the following.



System components

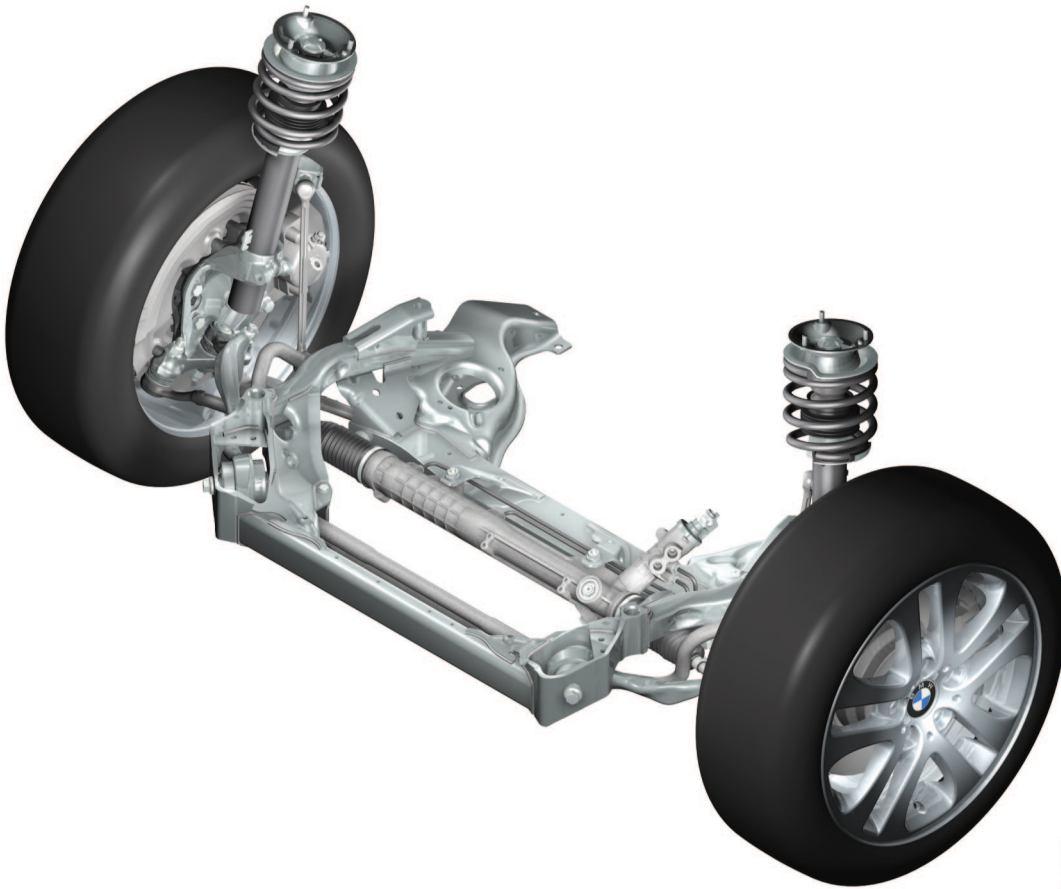
Suspension E90

E90 front axle

Double pivot spring strut front axle

Although a tension strut version of the double pivot spring strut front axle has been used in BMW vehicles for over 25 years, some of the

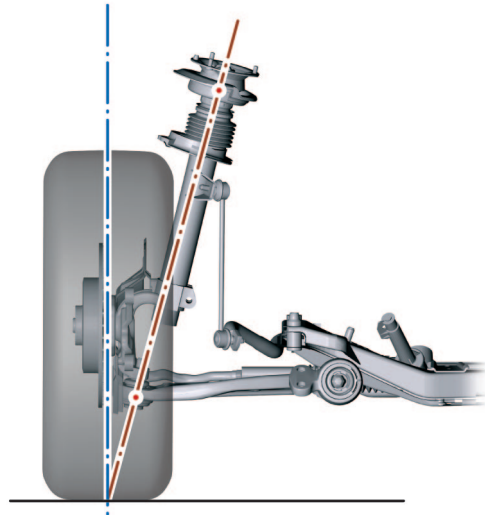
advantages, specifically compared to the single-joint or pivot spring strut front axle, are listed in the following.



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1 - E90 front axle

Both a positive (+) as well as a negative (-) kingpin offset can be achieved by realizing the virtual "pivot axle" (also known as "spreading axle", "steering pivot" or "steering axle").



2 - Pivot axle/steering axle

TF03_3991

However, when taking into consideration the self-stabilizing effect of a negative kingpin offset in connection with asymmetrical braking forces, this presumption is justified only under uniform deceleration conditions (in the stationary or steady range). In the unsteady case, i.e. at the start of the braking procedure, an implausible steering wheel movement occurs that could convey to the driver a false impression of the driving situation.

In addition, driving tests have shown that a stabilizing effect is also achieved at a small positive kingpin offset.

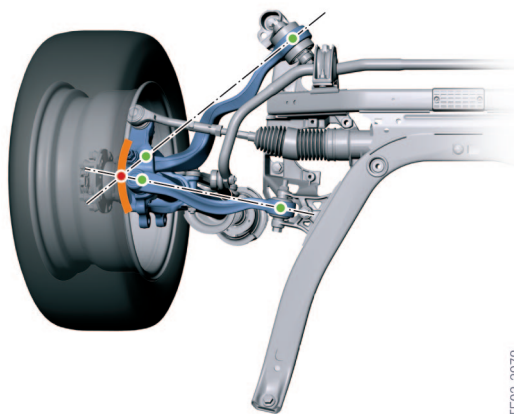
In view of the many other influencing factors such as the castor angle, moment of inertia of the vehicle, width of the tyre contact surface, etc. a fundamental explanation of this characteristic is provided.

The overall vehicle handling is also considerably more harmonious with the double pivot spring strut front axle designed with slightly positive kingpin offset.

Likewise, realization of the virtual "pivot axle" has a favourable effect on the package space for the brake discs and brake callipers.

In the case of the single-joint or pivot spring strut front axle, the wheel control joint is largely determined by the size of the kingpin offset. Since the kingpin offset should be as small as possible, the wheel control joint must be located as far towards the outside as possible. This however results in problems concerning the package space for the brake disc and brake calliper. On the double pivot spring strut front axle the position of the control arm and tension strut with respect to each other determines the size of the kingpin offset.

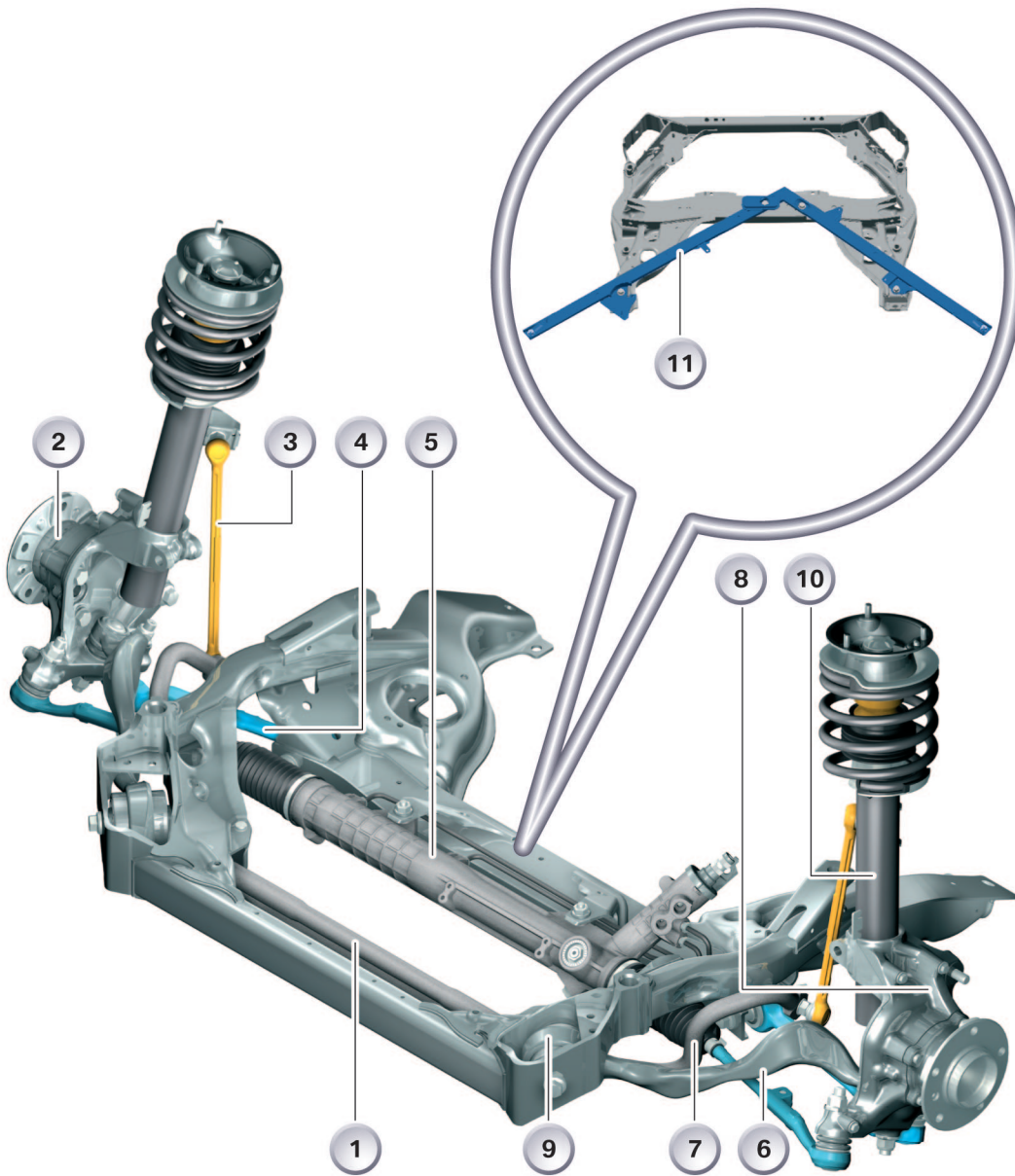
The pivot points of the control arm or wishbone and tension strut at the swivel bearing can therefore be selected such that no space problems are encountered for the brake system.



3 - Double pivot spring strut front axle/determining the lower pivot point

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Initially, it was thought that a negative kingpin offset should always be selected.



TF04-6271

4 - Components of E90 front axle

| Index | Explanation | Index | Explanation |
|-------|--------------------------|-------|--------------------------------|
| 1 | Front axle carrier | 7 | Stabilizer bar |
| 2 | Wheel hub | 8 | Swivel bearing |
| 3 | Stabilizer link | 9 | Hydro-mount |
| 4 | Control arm | 10 | Spring strut |
| 5 | Rack-and-pinion steering | 11 | Reinforcing strut (not in E87) |
| 6 | Tension strut | | |

Both tension struts are mounted with hydraulic mounts in the front axle carrier.

In addition, the distance of the tension strut and control arm pivot points at the swivel bearing largely determines the vertical force lever arm.

The greater the joints of the tension strut and control arm are from each other at the swivel bearing, the greater the weight reset force.

On the single-joint spring strut front axle, the distance is generally zero as the two joints of this axle have, as it were, merged to form one. The resulting advantage of the double pivot or joint spring strut front axle is improved directional stability in the high speed range and a lower tendency to steering instability in the lower speed range (insignificant for steering wheel torsional vibration LDS).

Compared to that of the control arm, the ball joint (guide joint) of the tension strut is raised at the swivel bearing, thus providing effective anti-dive control. A further advantage of this arrangement is that this tension strut mount on the axle carrier can be arranged at approximately the same level with respect to the mounting at the swivel bearing and does not have to be lowered. This is of particular benefit to a large overhang angle. In addition, it is possible to lower the control arm mount on the axle carrier side, thus enabling a lower roll centre.

The single-joint spring strut front axle features only one type of cross brace as the axle carrier.

The double pivot spring strut front axle on the other hand features a frame which additionally provides significant stiffening of the front end.

Technical data

| Explanation | Value | Explanation | Value |
|---------------------|---------|-------------------|------------|
| Total toe-in | 14' | Kingpin offset | 6,1 mm |
| Track width | 1500 mm | Wheel lock | 41° 5' |
| Camber | -18' | Wheel lock, outer | 33° 18' |
| Kingpin inclination | 14° 7' | Offset | 34 mm |
| Caster angle | 7° 5' | Tyre size | 205/5 R 16 |
| Caster | 19.8 mm | | |



E90 rear axle

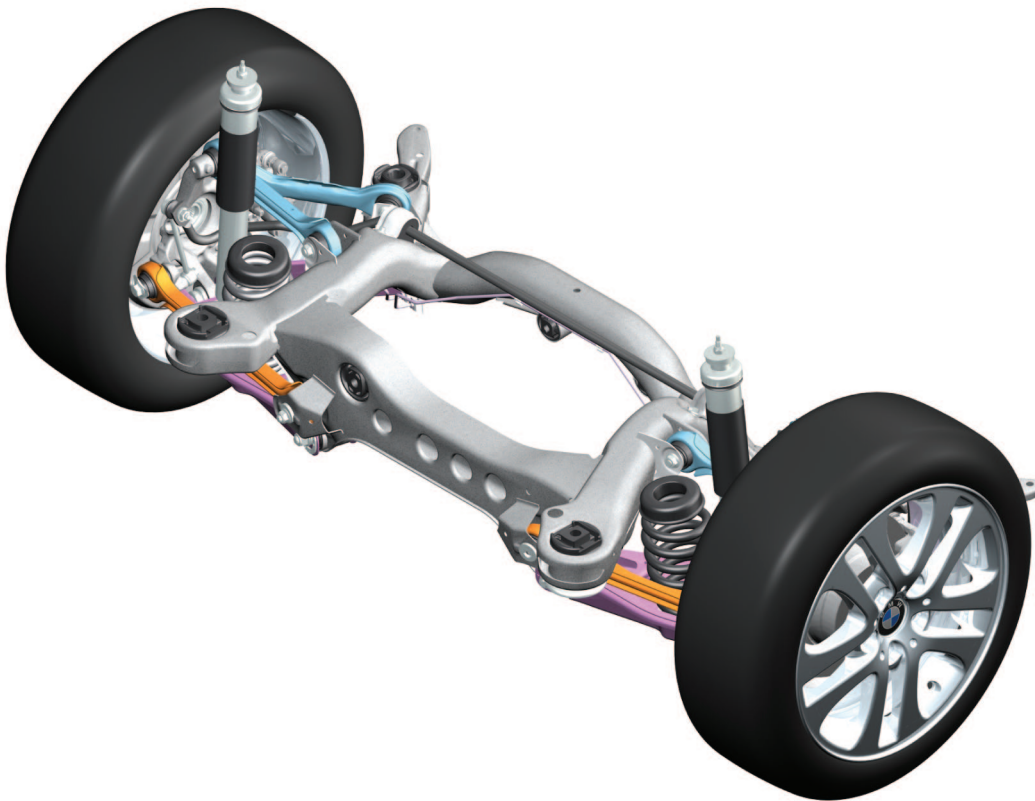
General

The newly developed rear axle with the development designation "HA 5" was used for the first time in the E87 and features again in the E90.

The designation "HA 5" does not refer to the five links but rather represents the consecutive development designation used at BMW (see models).

It is designed as a multi-link independent rear suspension axle with 5 different link arms.

Advantages



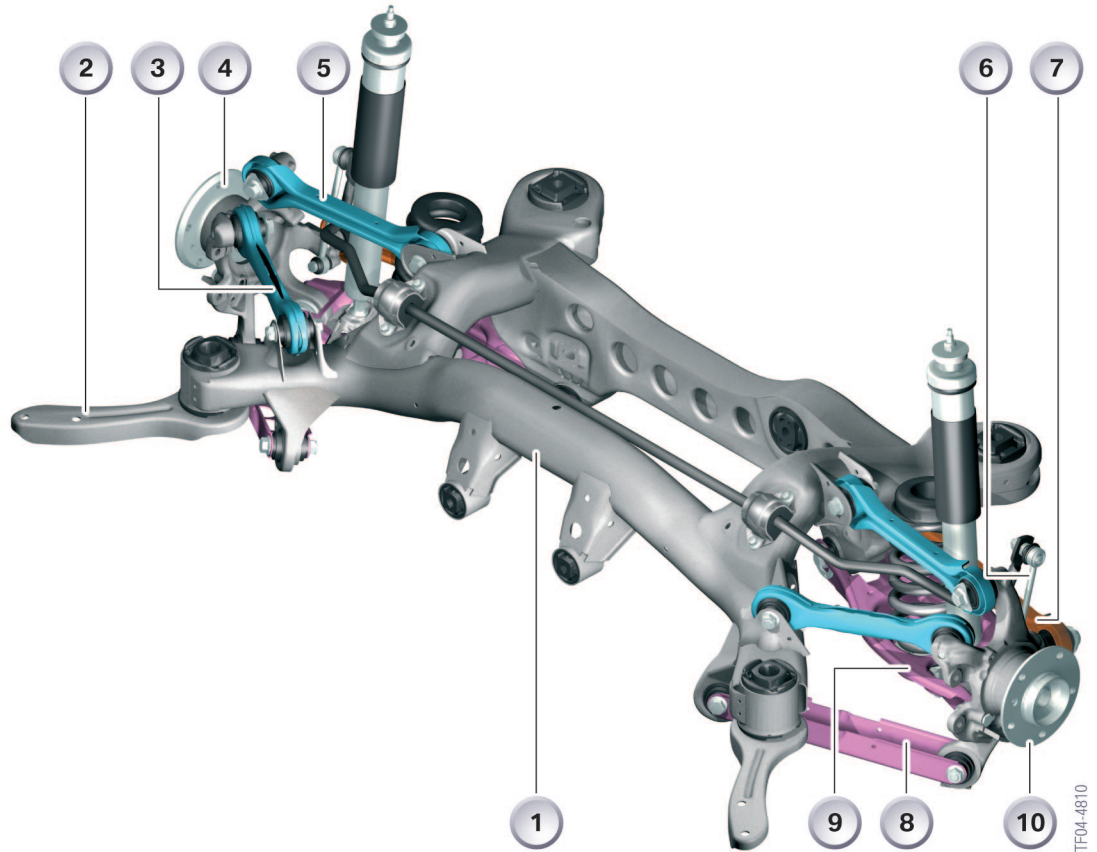
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5 - E90 rear axle

The names of the individual links are defined in the following graphic.



Components of the rear axle



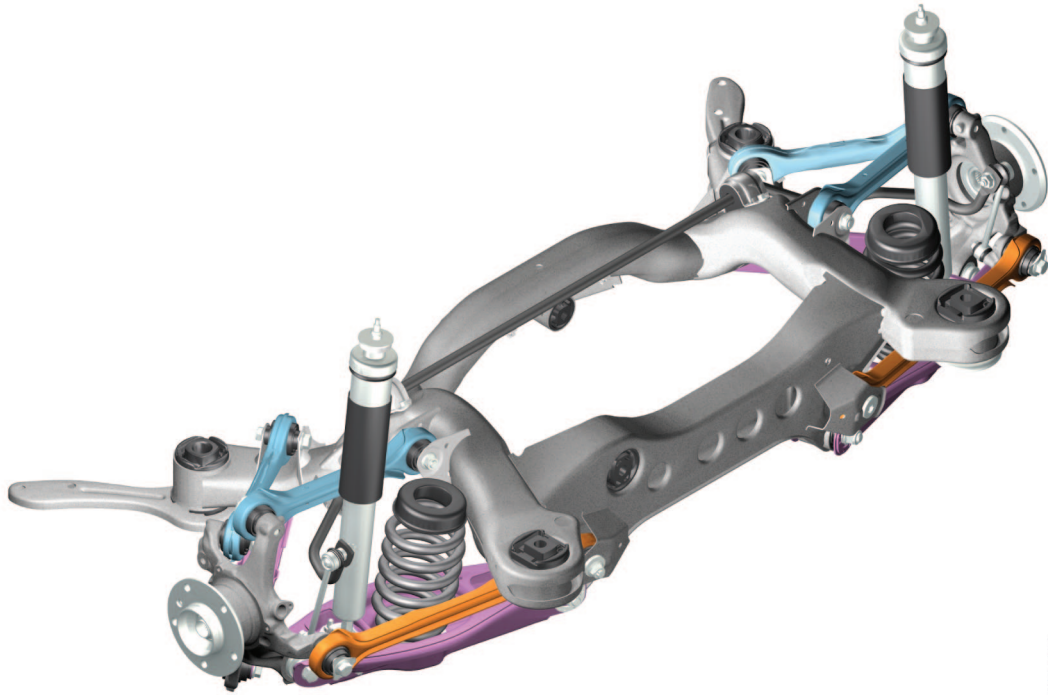
6 - Components of E90 rear axle

| Index | Explanation | Index | Explanation |
|-------|-------------------|-------|-------------------|
| 1 | Rear axle carrier | 6 | Stabilizer link |
| 2 | Thrust rod | 7 | Track link |
| 3 | Traction strut | 8 | Semi-trailing arm |
| 4 | Wheel hub | 9 | Camber link |
| 5 | Control arm | 10 | Wheel carrier |

Differences between the HA 5 in the E87 and in the E90:

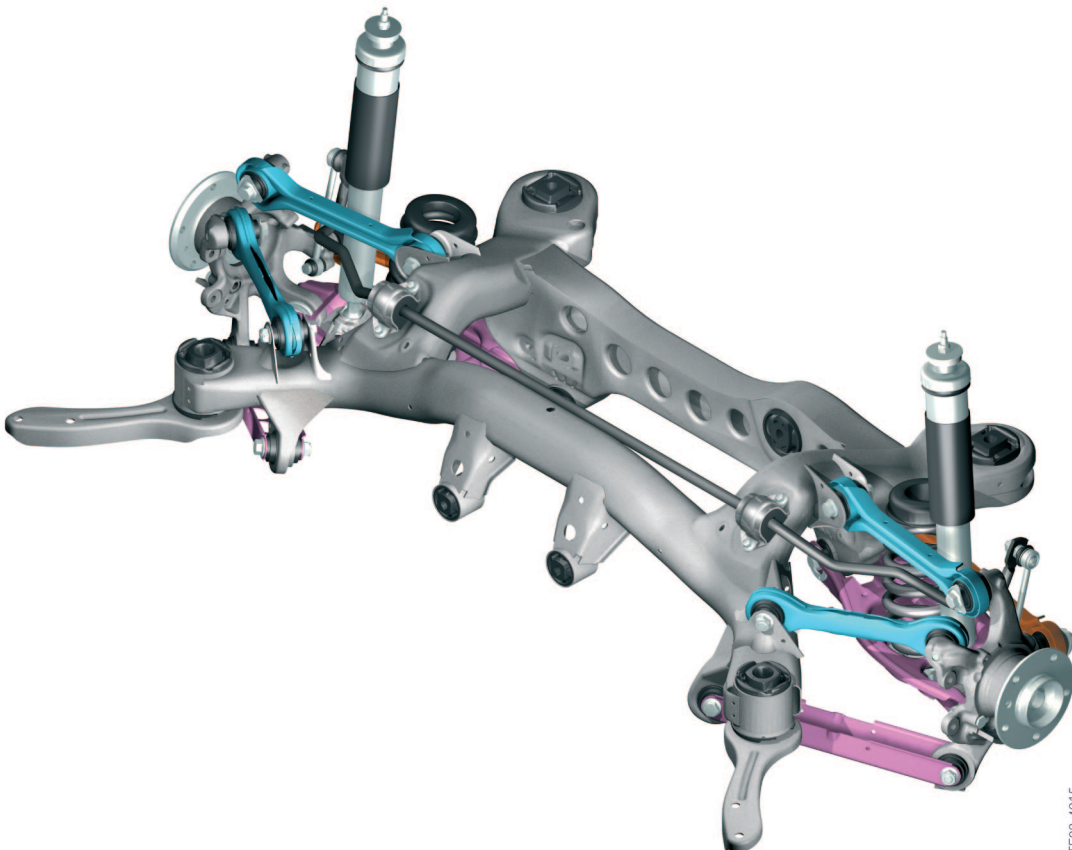
The structural design of the rear axle is the same in both vehicles. In the AWD version and in petrol/gasoline engines from 3.0 litres, the E90 has modified wheel carriers (10) with bigger wheel bearings. Likewise in all variants the rear axle transmission mounting is matched to the relevant drivetrain.

⚠ Different types of wheel-speed sensors are installed in the E90 (four- and six-cylinder models) depending on the relevant DSC (Dynamic Stability Control). ◀



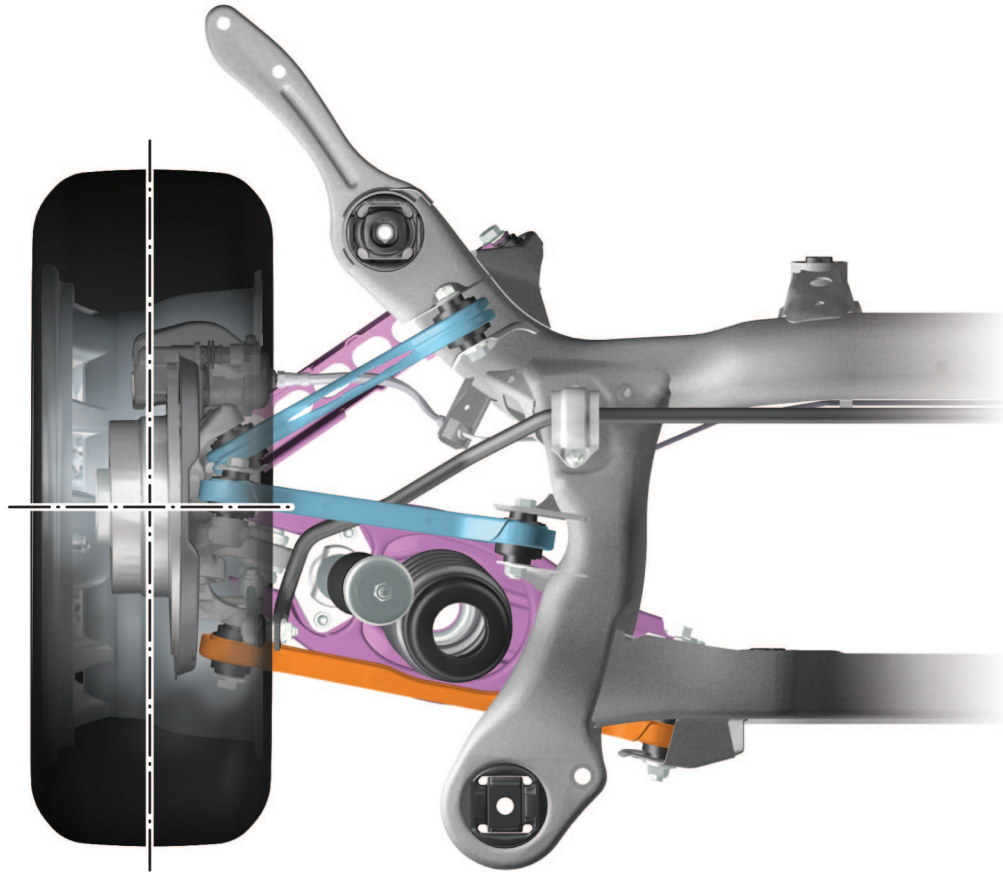
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7 - Rear axle from rear left (top)



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8 - Rear axle from front left (bottom)



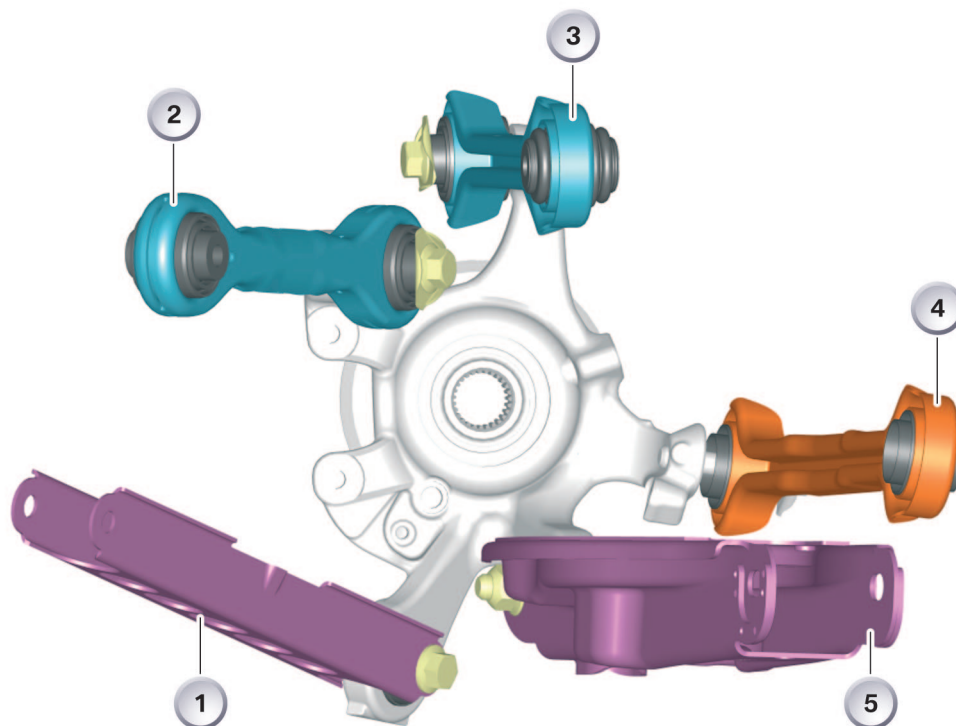
9 - Top view of rear axle, left

Various links of HA 5

The two upper links (blue in the illustration) form a triangle in the top view as do the two lower links (purple in the illustration).

The rear link (orange in the illustration) represents the track rod.

TF03-4304



TF04-4582

10 - Rear axle carrier from right

| Index | Explanation | Index | Explanation |
|-------|-------------------|-------|-------------|
| 1 | Semi-trailing arm | 4 | Track link |
| 2 | Traction strut | 5 | Camber link |
| 3 | Control arm | | |

Advantages of the new rear axle

The right-hand wheel carrier with the five different links of the HA 5 is shown in forward direction.

The rear axle carrier and the links are made from high strength steel. The wheel carrier is cast from GGG 40.

Compared to the previous rear axles, the HA 5 offers the following advantages:

Manufacturing costs

The lower costs are attributed to the fact that the use of high strength steel has made it possible to reduce the wall thicknesses of the rear axle carrier and of the links.

Compared to the integral IV, a considerable saving potential has been exploited by manufacturing the entire axle from high strength steel and the HA 5 rear axle does not have an excessively high weight.

Light construction

A bending moment occurs only in the camber link as the spring and damper are supported on this link. The remaining four links are not subjected to moments of force thus enabling a lightweight and rigid design.

Thanks to the straight design of the links and the connection by means of ball joints, apart from the camber link, all links transmit only tensile and compressive forces.

Consequently, the wheel control with this axle is subject to only minimal elasticity and is very precise.

Production

The HA 5 rear axle can be completely preassembled and adjusted with the brake system as well as the suspension and damping. This is a particular advantage for the production plants as it reduces cycle times.

Kinematics

The very small positive kingpin offset guarantees insensitivity to longitudinal forces even in connection with wide tyres.

The relatively large caster ensures a defined degree of lateral force understeering and therefore obliging vehicle handling. This method of vehicle stabilization offers the fastest response and is therefore also the best.

The change in toe as part of the suspension action enables outstanding directional stability with a relatively short wheelbase and exceptional self-steering characteristics while cornering.

The change in camber as part of the suspension action is selected such that an optimum camber with respect to the road surface is always established while cornering. Nevertheless, the change in camber during spring compression due to load is not too great as to cause increased tyre wear. As a result, new lateral force potentials are utilized together with RSC tyres (tyres with runflat properties).

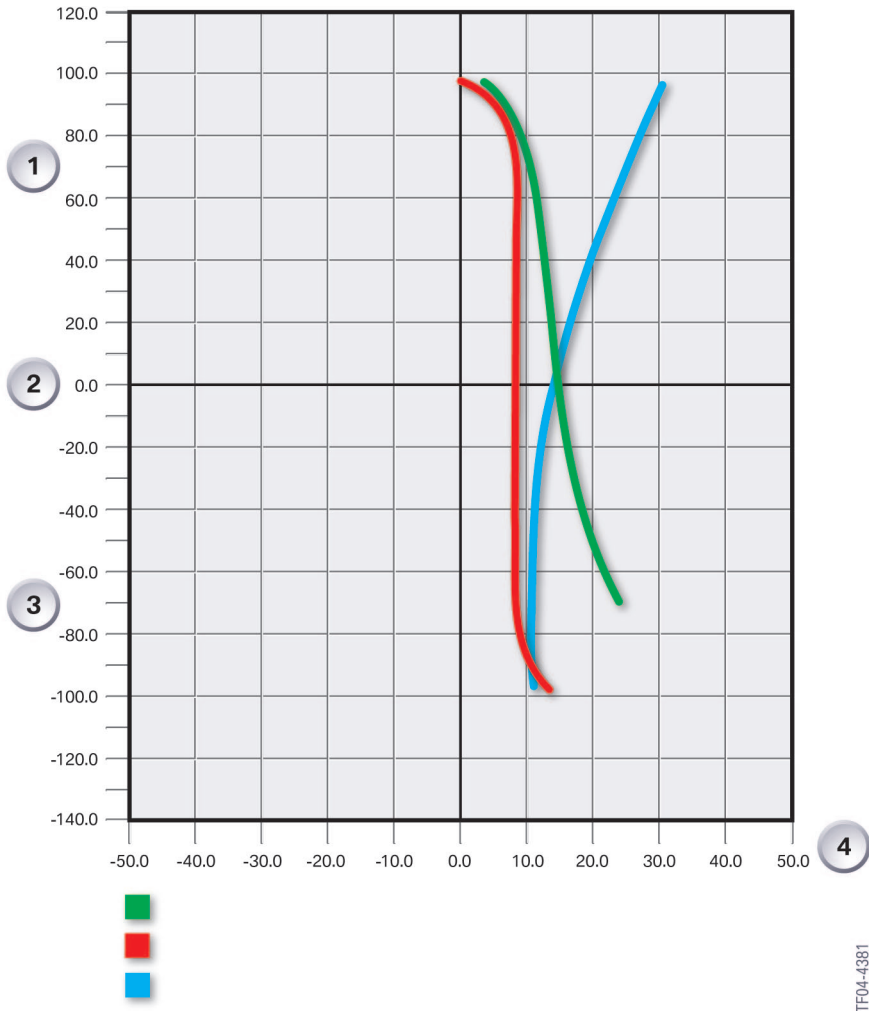
The long design of the track link makes for outstanding length tolerance insensitivity. The long track link also has a positive effect on the toe-in characteristics over the spring travel range.

The low roll centre has a particularly beneficial effect on the rolling motion.

The "propping" effect while cornering has been largely minimized by improving the roll centre change rate.




The braking support has been set to 70 %. Racing cars generally have a support angle of 0 % in order to constantly achieve maximum contact force. On these vehicles, the disadvantage of a dive motion while braking and starting off is compensated by the taut suspension. The braking support (anti-dive) realized on the E87 and E90 represents an optimum compromise between comfort, safety and driving dynamics requirements.

The use of five links enables free selection of the pivot axle for the design layout. This means that the movement of the wheel in interaction with the suspension can be optimized without compromise under braking, acceleration and lateral forces. This largely determines all important variables such as toe, camber, brake support (anti-dive) angle, roll centre and roll centre change rate.



11 - Toe characteristics over the rear axle spring range

TF04-4381

| Index | Explanation | Index | Explanation |
|---|--|---|---|
| 1 | Spring compression | 3 | Spring deflection |
| 2 | Spring travel range [mm] | 4 | Track [min.] |
|  | Toe-in change over spring travel range under braking force |  | Toe-in change under spring compression and deflection without force |
|  | Toe-in change over spring travel range under lateral force | | |

Crash requirements

The frame side member had to be cranked to a relatively large extent in connection with the semi-trailing arm and central-link rear axle. This brought about disadvantages in connection with a rear end impact. In contrast, the HA 5 rear axle permits a considerably more favourable progression of the side member,

resulting in specific advantages particularly at low impact speeds.

Added to this, the large rear axle carrier is connected directly to the rigid frame side member, allowing it to transmit the applied crash forces more favourably. The semi-trailing arm features crash beading (in the semi-trailing arm of the HA 5 rear axle, see Fig. 6) to ensure the fuel tank is not damaged.

Rigidity/acoustics

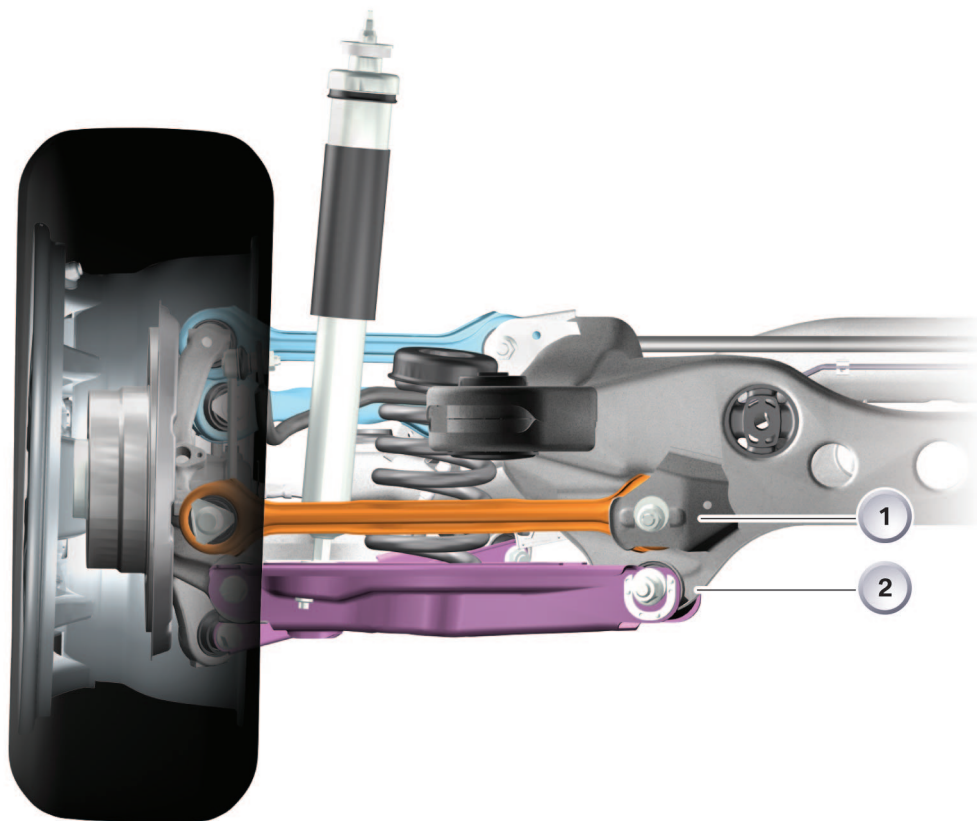
The rear axle carrier of the HA 5 rear axle extends up to the rigid frame side members of the body with its axle mounting points and even up to the sill with its thrust rods. This provides a very large support face for the applied forces and moments. The resulting advantages include, on the one hand, considerably lower stress and strain on the body (rear axle break-away) and, on the other hand, the option of designing the rear axle bearing mounts, which are wide apart, relatively soft. This arrangement and the double flexible mounting provide outstanding

insulation against road noise and tyre rolling noise.

Technical data (standard suspension, 7Jx16)

| Description | |
|----------------------|---------|
| Wheelbase | 2760 mm |
| Track width | 1513 mm |
| Offset | 34 mm |
| Tyre radius (static) | 291 mm |
| Total toe-in | 18' |
| Camber | -1° 30' |

Setting



12 - Track and camber settings (rear view)

| Index | Explanation |
|-------|------------------------|
| 1 | Track adjusting screw |
| 2 | Camber adjusting screw |

TF04-4518



Electric steering lock

History

Electric steering lock (ELV)

The complete system was installed for the first time in the E87. It consists of a start/stop button, a remote control, the Comfort Access

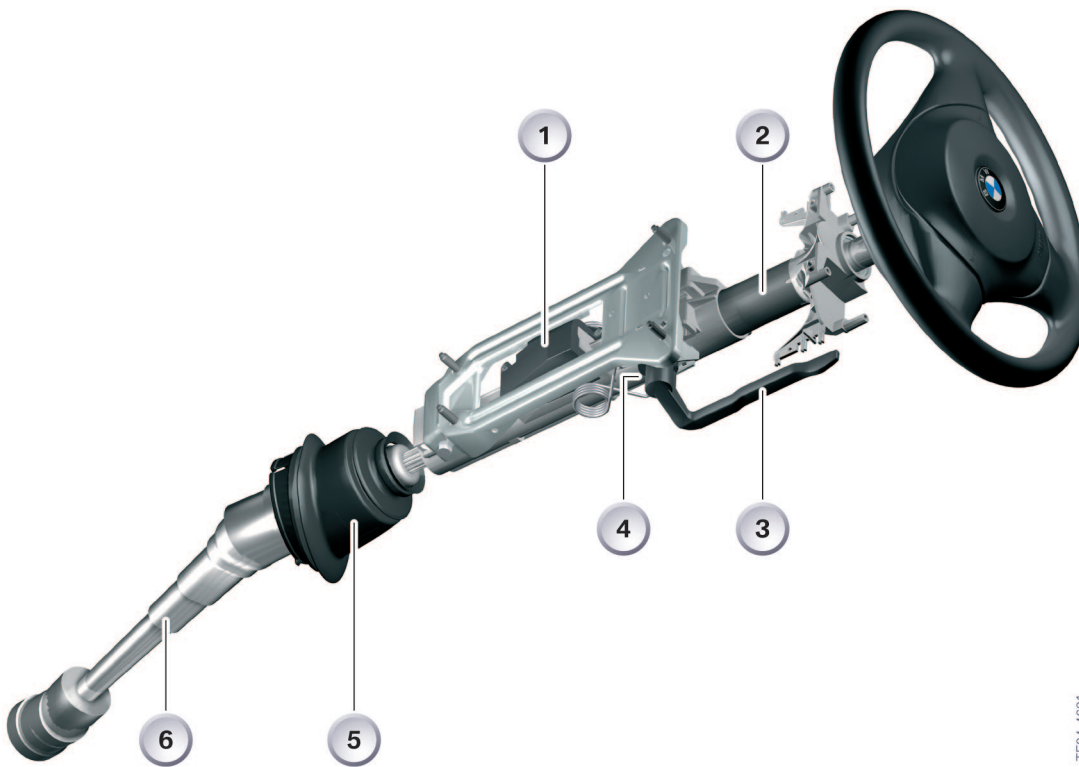
control unit (CAS) and the ELV. A further developed complete system is used in the E90 (and in the E87 from 11/04).

System and functional description

System and functional description

Together with the electric steering lock facility (ELV), the steering column forms one

component and may only be replaced as a complete unit. The ELV in turn consists of an electronic and a mechanical part.



13 - Complete steering column

TF04-4631

| Index | Explanation | Index | Explanation |
|-------|-----------------|-------|--------------------------------------|
| 1 | ELV | 4 | Catch for steering column adjustment |
| 2 | Crash element | 5 | Steering sleeve |
| 3 | Adjusting lever | 6 | Steering spindle |

Differences from ELV up to 10/04

- Three-pin plug now replaced by a four-pin plug with additional grounding cable
- Adaptations to electronic and mechanical elements (noise optimization)
- Steering column with ELV from 11/04 is not backward-compatible on replacement



Electronic part of the ELV

2x ground and a 12 volt voltage are applied to the four-pin plug connection. A K-bus line from the CAS delivers the necessary communication signal to the ELV.

The CAS monitors the various driving or standstill situations of the vehicle (signal from DSC) and is therefore also the control unit that triggers the unlocking (release) or locking action in the ELV. It also switches the ground and 12 V cable for locking and only the 12 V cable for unlocking (therefore new ground cable). Generally, no power is applied to the ELV when the vehicle is not stationary.

Mechanical part of the ELV

A locking lever with its position monitored by a sensor and a locking pin are the main components of the mechanical part designed to lock or unlock the steering column at the correct moment. The entire internal kinematic structure is designed such that a mechanical lock (locking lever) keeps the unlocked locking pin in position when no power is applied to the ELV.

Advantages of the ELV:

- Remote control as on the E65 in the form of a "bitless" key
- High 2-fault security (an electronic fault and a mechanical fault must occur simultaneously) in accordance with DIN Standard SIL3
- No steering wheel lock in knee impact area.
- The E90 can also be equipped with the Comfort Access option.

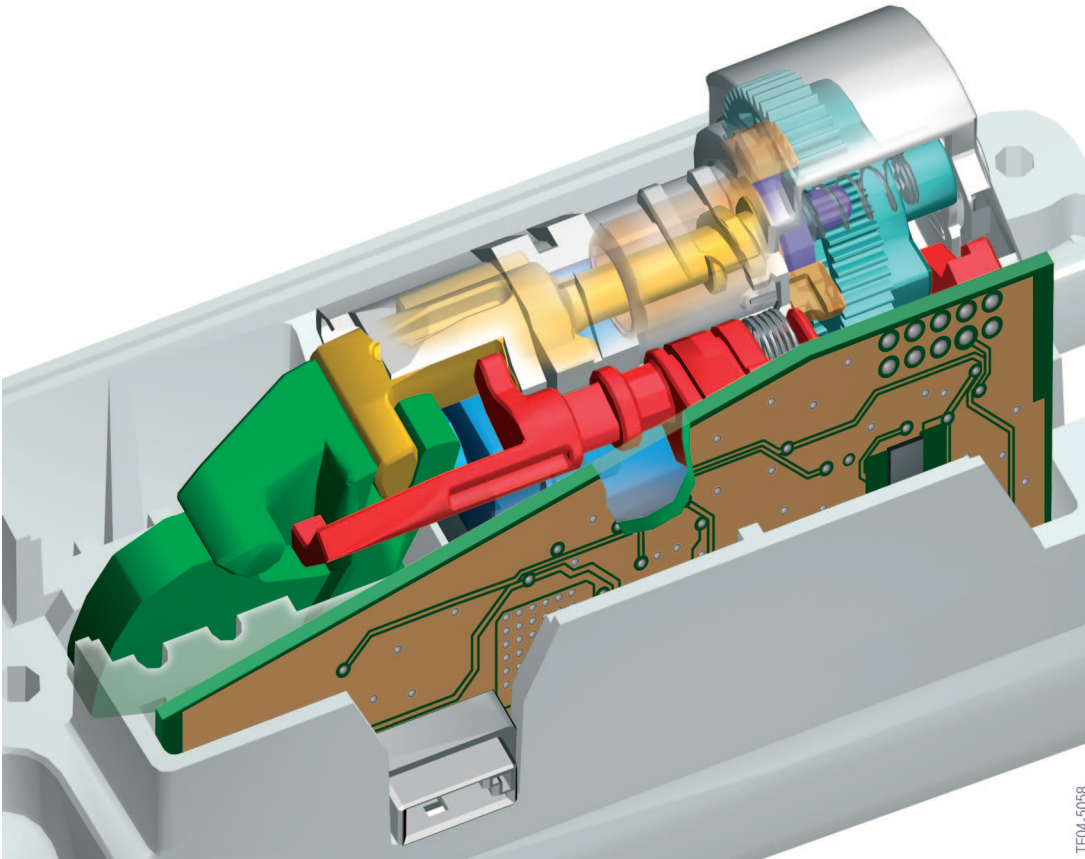
The E46 featured an infinitely variable clamp connection for the steering wheel up/down and in/out adjustment. An extremely closely-stepped catch connection is used in the E90 as in the E87.

The adjustment range has been extended and the user friendliness increased. The new adjustment unit now supports the airbag and the steering column. The upper area of the steering column and an integrated crash element (metal tube) are designed as load-bearing parts.

The metal tube is pre-perforated in a defined longitudinal area at the upper end of the steering column. In the event of an impact, this metal tube begins to crack at the predefined points. This perforation is required for the purpose of converting energy in the event of an impact.

The steering column must always be replaced after an airbag has triggered or the steering shaft is replaced!

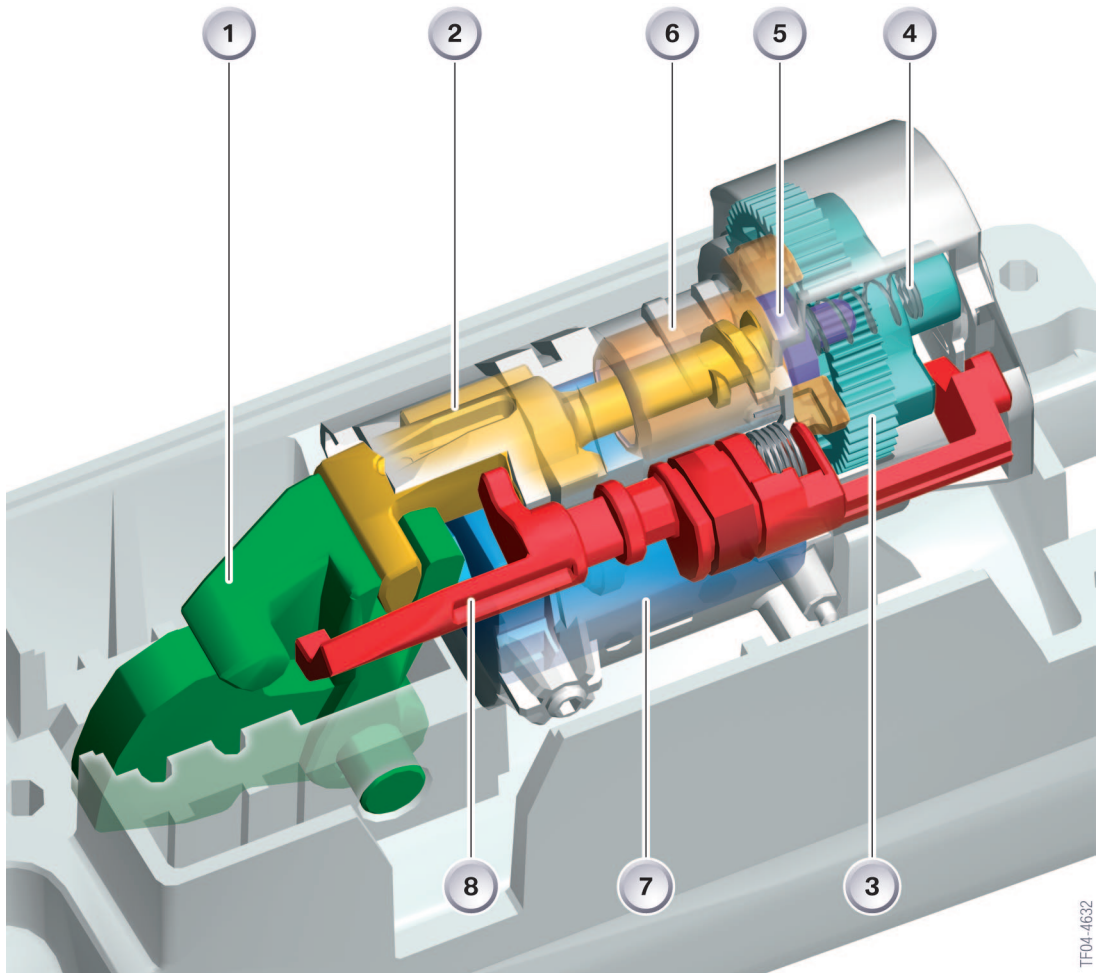
The steering spindle sleeve or collar is also new (as in the E87). On the E46, this collar was held in position by the pedal assembly. The new collar is connected in the bulkhead and is double-sided. This arrangement results in a lower reset force for the steering column height adjustment.



TF04-5038

14 - ELV assy without cover (opened)

In the following, the ELV is shown without the electronics and only the mechanism is explained.



TF04-4632

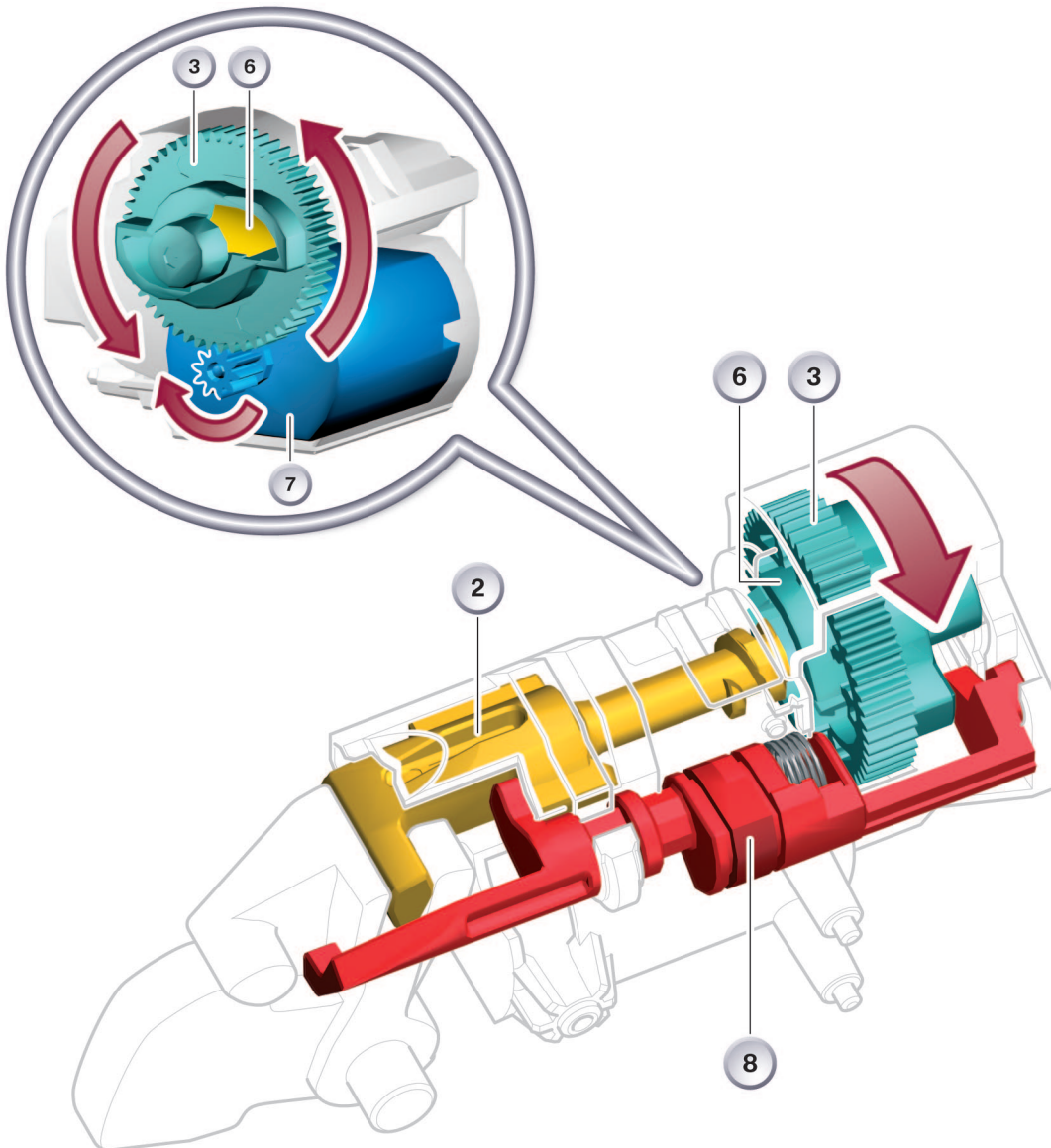
15 - ELV mechanism

| Index | Explanation | Index | Explanation |
|-------|--------------------------------|-------|----------------------------|
| 1 | Locking pin | 5 | Pressure plate |
| 2 | Driver with worm | 6 | Nut |
| 3 | Gearwheel with control contour | 7 | Electric motor with pinion |
| 4 | Spring | 8 | Locking lever |

The steering wheel is coded as in the E60 to prevent displacement.



Locking procedure

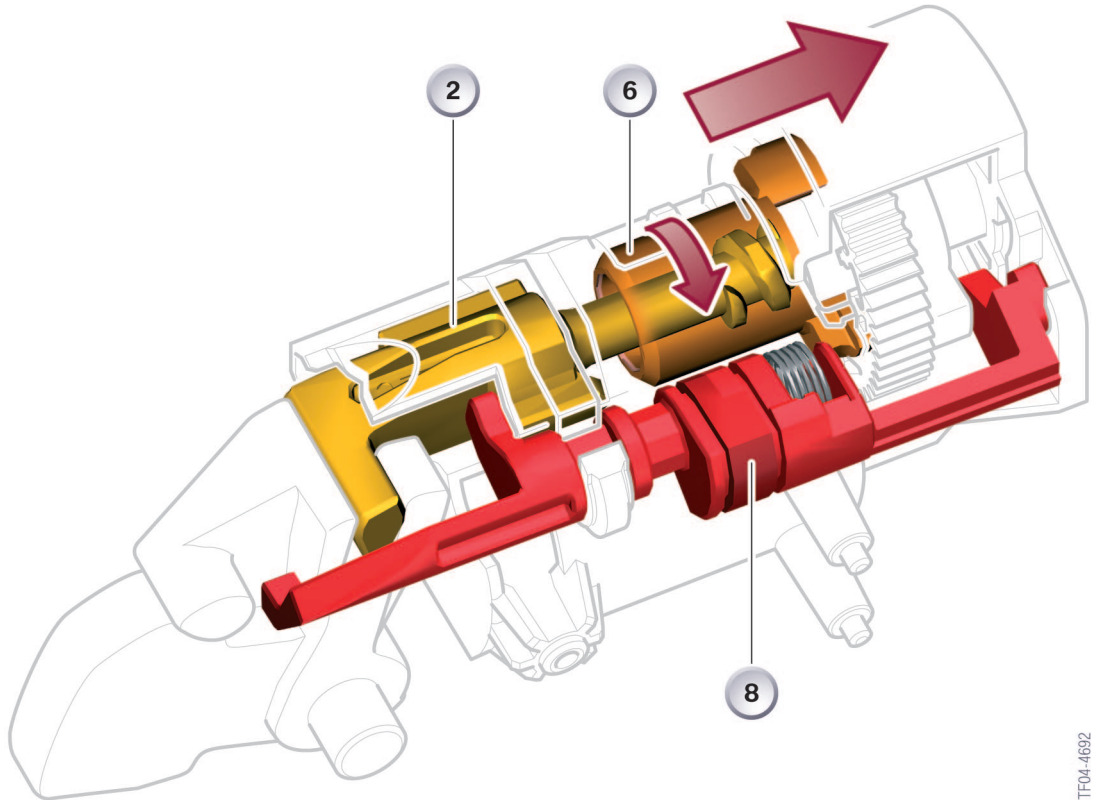


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16 - ELV mechanism

From the "unlocked" position, the electric motor (7) begins to turn the gearwheel with control contour (3) and the reclined mechanism.

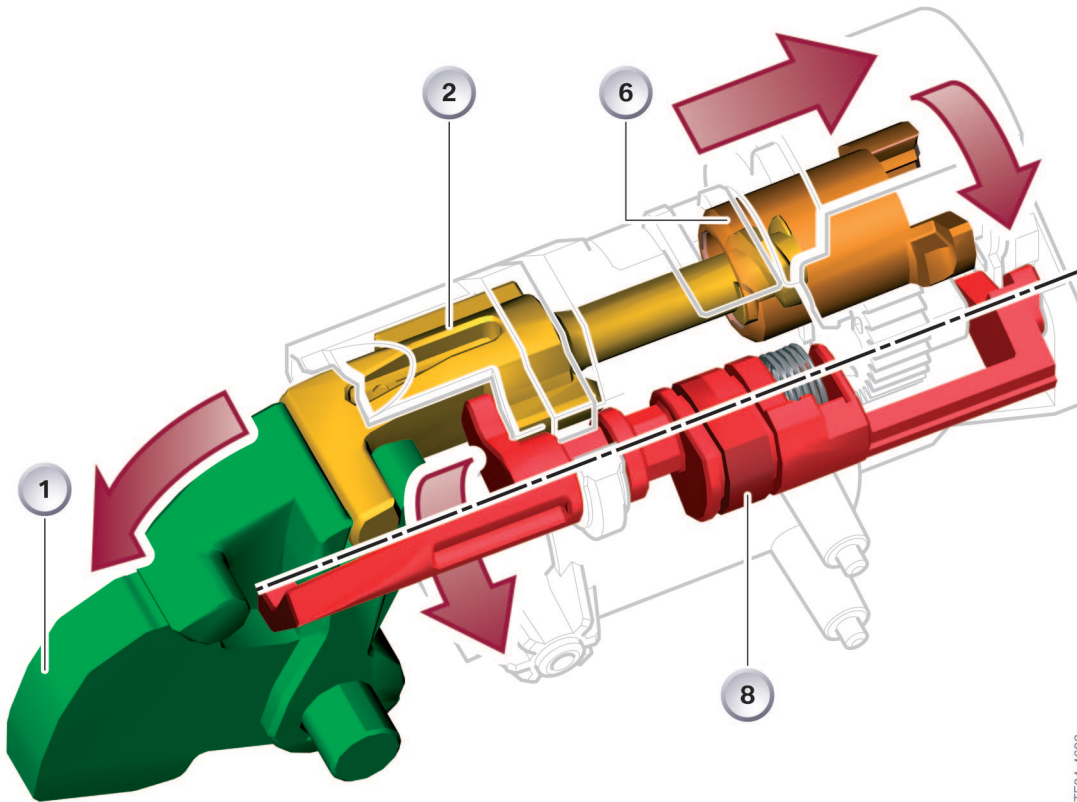
The drive carrier with worm gear (2) is blocked by the locking lever (8). The reclined nut (6) now begins to rotate.



17 - ELV mechanism

The nut (6) moves on the worm towards the locking lever (8).

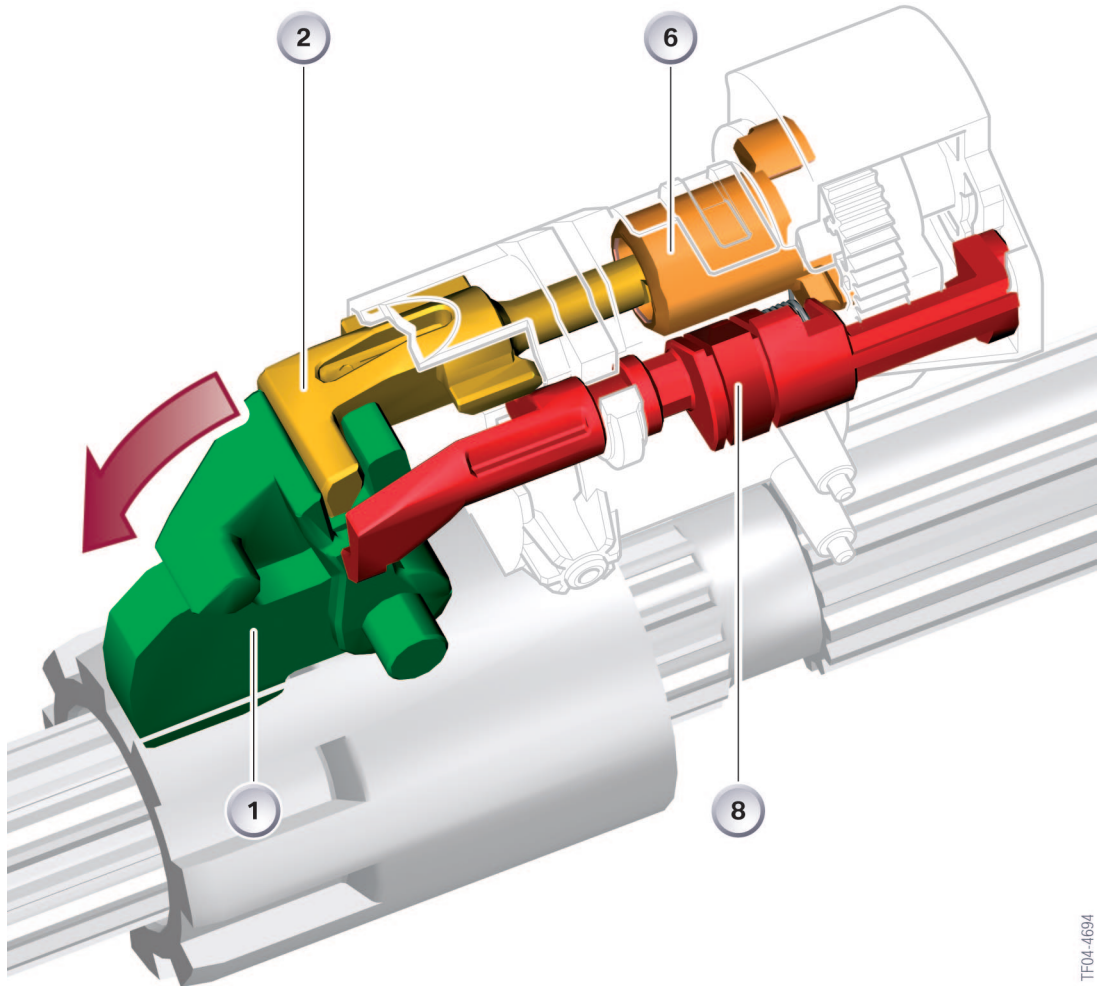
TF04-4692



18 - ELV mechanism

The locking lever (8) is now rotated by the control contour so that the drive carrier with worm (2) and locking pin (1) snap in position.

TF04-4693



19 - ELV mechanism

The locking pin (1) is snapped in with the mechanism in the locked position. The locking lever (8) rests on the drive carrier.

TF04-4694

Service information

Suspension E90

Summary

Electric steering lock

⚠ Together with the electric steering lock facility (ELV), the steering column forms one component and may only be replaced as a complete unit.

The steering column with ELV from 11/04 is not backward-compatible on replacement. ◀



Abbreviations

| | |
|-----|------------------------------------|
| CAS | Car access system |
| DSC | Dynamic stability control |
| ELV | Electric steering lock |
| LDS | Steering wheel torsional vibration |

